

Martins, José Manuel; Marques, João Lourenço; Silva, Carlos Jorge

Conference Paper

Estimating net migrations at regional and age-specific group levels

53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Martins, José Manuel; Marques, João Lourenço; Silva, Carlos Jorge (2013) : Estimating net migrations at regional and age-specific group levels, 53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/124111>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Estimating net migrations at regional and age-specific group levels

José Manuel Martins (jmm@ua.pt)

João Lourenço Marques (jjmarques@ua.pt)

Carlos Jorge Silva (carlosjorge@ua.pt)

Department of Social, Political and Territorial Sciences, Research Unit GOVCOPP,
University of Aveiro, Portugal

Abstract

Following the Mediterranean Region trend, the Portuguese peripheral NUTS III regions are simultaneously affected by a human desertification process and population ageing. In order to analyse the requirements to revert this process, DEMOSPIN project - *Economically Sustainable DEMOgraphy - ReverSing Decline in Peripheral RegIoNs* – developed a joint demographic-economic model, where migrations are the link between the economic and demographic dynamics.

The model estimates net migration for each age group, considering three kinds of migrants: i) the active age groups migrants (15-65 years old), responsive to job opportunities; ii) the older age groups (more than 65 years old), where migrations reverse the movements occurred in the past, and iii) the youngest age groups (less than 15 years old) which follow the parents migrations or are driven by opportunities to study elsewhere.

This model was based on the census data for 1991, 2001 and 2011 and was developed to estimate migration based i) on socioeconomic factors: creation or destruction of *employment* (split in primary and non primary sector), *GDP per capita* and *demographic potential* and ii) on the *ancient migration*, occurred 10, 20, 30, 40 or 50 years ago (for example, the migration of the 65 to 70 years old population related to migration of 25 to 30 years old, 40 years ago).

A satellite model was developed for migrants with ages below 15 years old where movement is related to parent's migration patterns.

The coefficients of the regression model are specific to each age group and sex.

The results show a very high adjustment for younger groups, between migration and socioeconomic drivers. For people older than 40 years, such adjustment is lower but it is partially compensated by the effect of migrations occurred in the past. Globally, the model provides an accurate description of NUTS III migration patterns.

This paper will present first the migration patterns of the Portuguese peripheral regions and the theoretical basis of migration estimation models and its determinants. Afterwards, it will describe the methodology underlying the model construction and the results obtained, providing a deeper understanding of the migration dynamics of the regions under study.

Keywords: input-output and demographic integrated model, migration modeling, peripheral regions, simultaneous estimation

1. Introduction

The peripheral regions of Portugal, corresponding to 50% of the territory and 20% of the population, are declining in population; their economy shows also an associated declining tendency. Project DEMOSPIN - *Economically Sustainable DEMOgraphy ReverSing Decline in Peripheral RegIoNs* - funded by the Portuguese Foundation for Science and Technology aims to develop a tool to support the definition of policy strategies concerning the development of demographically depressed regions. The methodology will combine demographic projection techniques with regional growth models relating the net creation of new jobs to the expected net migration (Castro et al, 2012-a (1), Ramos et al, 2011 (2)).

The outputs are estimates of economic growth and population evolution in peripheral Portuguese regions up to 2030, according to different socio-economic scenarios. The estimates will support policies to revert the demographic decline of these peripheral areas. Low fertility rates and the shortage of women in fertile age, make this reversal only possible by attracting young population moving in response to job opportunities.

In this paper we present the model developed in order to tackle the peripheral regions migration issue. The model explains net migration in each region as a function of net creation

of employment, GDP per capita and demographic potential. The obtained results confirm our expectations: the model has a high capacity to predict net migrations for the groups corresponding to working age. As it was also expected, the model gives lower coefficients of determination for elderly people net migration, whose motivations to migrate are in general less related to job opportunities. A different model to deal with elderly people migrations is presented in this paper. In which concerns net migrations for groups under working age, they are assumed to occur inside household's movements and thus they are estimated as a function of net migrations for working age people.

2. Demographic evolution of the Portuguese population

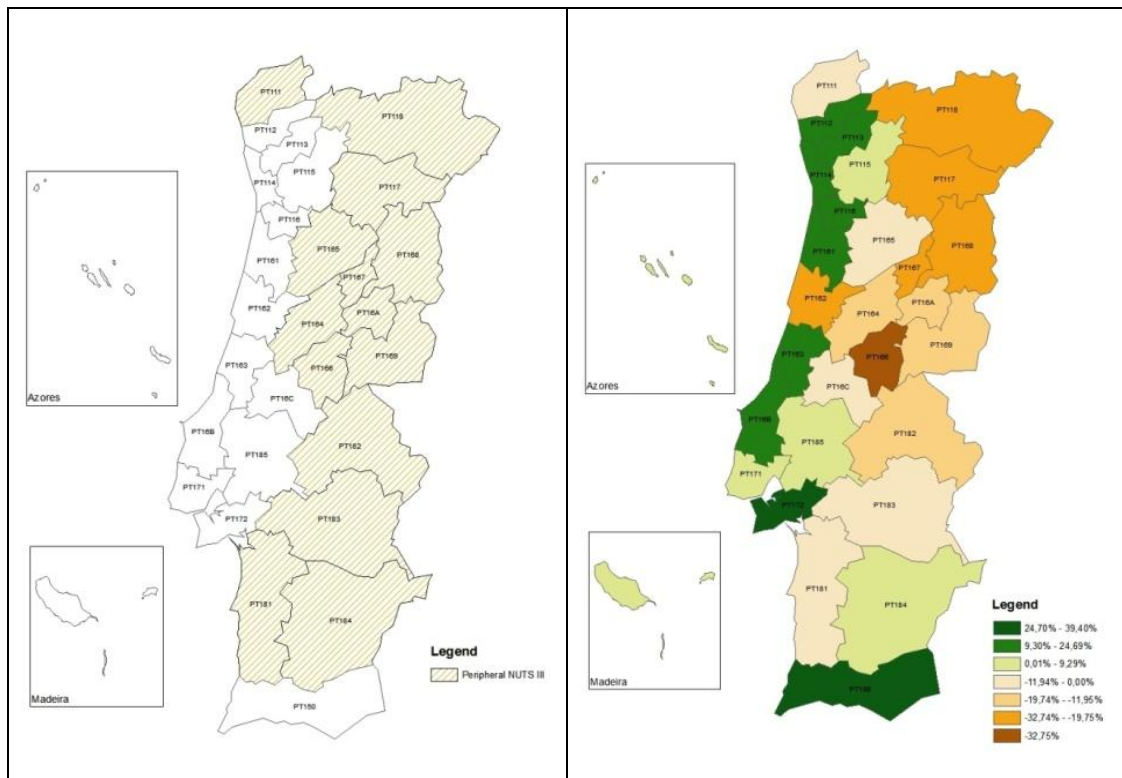
The Portuguese demographic evolution is characterized by a process of population concentration along the coast, through a process of continuous and simultaneous urban and industrial agglomeration. This process leads to a significant decrease in the volume and ageing of population in most peripheral NUTS III, in spite of the slight increase in the total Portuguese population.

A detailed analysis of the evolution of the last three decades was presented in Castro et al, 2012-a (1). Figure 1 (A) identifies the Portuguese NUTS III under consideration and what is considered the peripheral and the coastal areas; figure 1 (B) presents a synthesis of population demographic changes, by NUTS III. It is evident the displacement of population from the periphery to the coast, associated with the decrease of the natural dynamics.

Along with population change, the ageing process took place quickly and intensively. Since 1981 the proportion of young population, (0-14 years old) decreased in all regions, though less markedly in the coastal NUTS III. The opposite occurred in the evolution of elderly population (65 years old and more), whose proportion increased all over the period, with a stronger incidence in the peripheral regions.

The demographic dynamics is also reflected in the evolution of working-age population. Because the decrease of the youngest was stronger than the increase of eldest people, the percentage of working-age population increased generally, but with a marked regional contrast: while there was a clear growth in the coastal areas and in the islands, the percentage remained stable or even decreased in the periphery, as a consequence of a more mature ageing process (Castro et al, 2012-a (1)).

There is a marked contrast between a coastal zone which, in spite of the ageing process which is occurring in almost all Western Countries, has still a moderate positive demographic dynamics, and a periphery where ageing is coupled with a sharp demographic decline.



Source: Statistics Portugal Census 1981, 1991, 2001 and Provisional data from the 2011 Census

Figure 1 - (A) Portuguese regions codes; (B) Portuguese population growth (1981-2011)

3. Migration trends

Migrations are a very important driver of Portuguese population evolution. The natural growth of population is still positive but it is decreasing and was marginal in the last decade; furthermore, it is expected to become negative in the near future. In the last two decades population growth was mainly the outcome of a positive net migration and the continuation of growth is only possible if this population inflow is maintained, something that the present crisis makes much unlikely. The contrast between the coast and the periphery is marked: though decreasing, the growth of coastal regions was maintained in both the natural and migration components, while in the periphery a sharp natural decline was only partially compensated by migrations which are now averaging zero (table 1). The present crisis will turn the situation significantly worse than what is depicted in this paper.

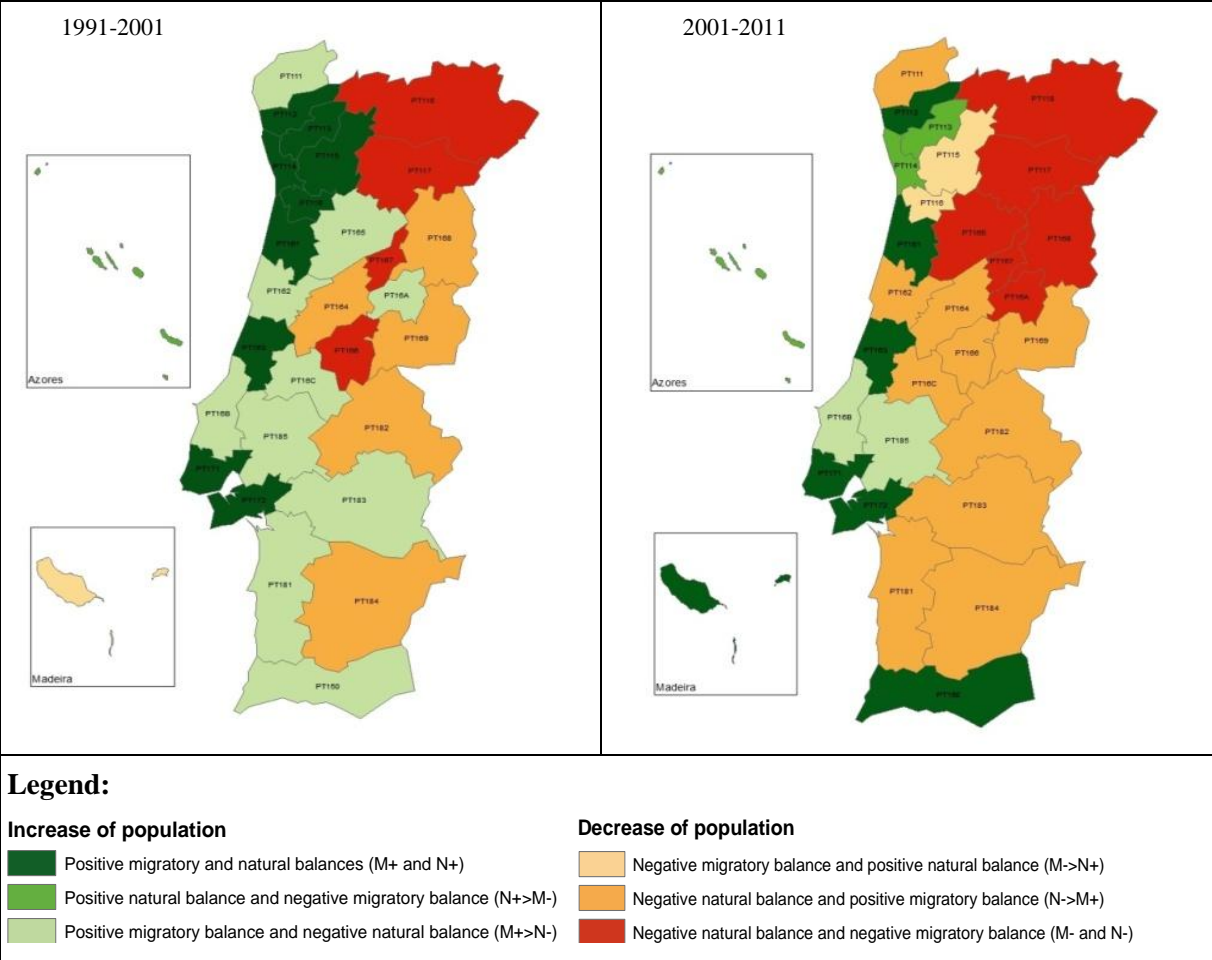
Table 1 – Portuguese population growth rates

	Regions NUTS III	Region code	1991-2001			2001-2011		
			Rate of total increase	Rate of natural increase	Rate of net migration	Rate of total increase	Rate of natural increase	Rate of net migration
Peripheral NUTS III	Minho-Lima	PT111	0,1%	-2,2%	2,3%	-2,1%	-3,3%	1,2%
	Douro	PT117	-7,0%	-1,8%	-5,3%	-7,2%	-4,1%	-3,0%
	Alto Trás Montes	PT118	-5,0%	-4,3%	-0,8%	-8,3%	-6,2%	-2,0%
	Pinhal Interior Norte	PT164	-0,7%	-5,9%	5,2%	-5,3%	-6,4%	1,1%
	Dão Lafões	PT165	1,4%	-1,5%	2,9%	-2,9%	-2,8%	-0,1%
	Pinhal Interior Sul	PT166	-11,8%	-9,4%	-2,5%	-9,1%	-11,7%	2,6%
	Serra Estrela	PT167	-7,7%	-5,9%	-1,8%	-12,4%	-8,8%	-3,6%
	Beira Interior Norte	PT168	-2,7%	-5,8%	3,1%	-9,5%	-7,6%	-1,9%
	Beira Interior Sul	PT169	-3,6%	-7,5%	3,9%	-4,2%	-8,4%	4,2%
	Cova Beira	PT16A	0,5%	-4,0%	4,5%	-6,2%	-4,4%	-1,9%
	Alentejo Litoral	PT181	1,5%	-4,8%	6,2%	-2,1%	-4,9%	2,8%
	Alto Alentejo	PT182	-5,6%	-6,1%	0,5%	-6,4%	-7,8%	1,3%
	Alentejo Central	PT183	0,2%	-3,6%	3,9%	-3,5%	-4,3%	0,8%
	Baixo Alentejo	PT184	-5,6%	-7,0%	1,4%	-6,3%	-7,1%	0,8%
	Total peripheral Regions			-2,63%	-4,11%	1,48%	-5,42%	-5,36%
Coastal NUTS III	Cávado	PT112	11,4%	6,6%	4,8%	4,5%	3,9%	0,6%
	Ave	PT113	9,5%	6,2%	3,3%	0,3%	2,6%	-2,4%
	Grande Porto	PT114	8,0%	3,5%	4,5%	2,0%	2,1%	-0,1%
	Tâmega	PT115	8,4%	7,2%	1,2%	-0,1%	3,4%	-3,5%
	Entre Douro e Vouga	PT116	9,8%	4,9%	4,9%	-0,6%	2,0%	-2,6%
	Baixo Vouga	PT161	10,1%	1,8%	8,3%	1,3%	0,3%	1,0%
	Baixo Mondego	PT162	3,5%	-1,3%	4,8%	-2,4%	-2,4%	0,0%
	Pinhal Litoral	PT163	12,5%	1,8%	10,8%	4,1%	0,8%	3,3%
	Oeste	PT16B	7,3%	-1,2%	8,5%	6,6%	-1,1%	7,7%
	Médio Tejo	PT16C	2,1%	-3,3%	5,4%	-2,2%	-3,5%	1,3%
	Grande Lisboa	PT171	3,6%	1,2%	2,4%	4,7%	2,4%	2,3%
	Península Setúbal	PT172	11,6%	1,8%	9,8%	8,9%	2,5%	6,4%
	Lezíria Tejo	PT185	3,3%	-3,3%	6,6%	2,9%	-2,8%	5,7%
	Algarve	PT150	15,7%	-1,9%	17,6%	14,0%	0,1%	13,8%
	R A Açores	PT200	1,8%	3,7%	-1,9%	1,8%	2,0%	-0,2%
R A Madeira	PT300	-3,3%	2,5%	-5,8%	9,4%	0,8%	8,5%	
Total coastal Regions			7,03%	2,21%	4,82%	3,73%	1,53%	2,20%
Portugal			4,98%	0,87%	4,11%	1,93%	0,17%	1,76%

Source: Statistics Portugal Census 1981, 1991, 2001 and provisional data from the 2011 Census

The figures below summarize the dynamics shown in the table above. The number of NUTS III with positive natural and migration growth rates decreases as well as the number of NUTS III with positive natural growth rate. It is important to stress that in 2001-2011 there are 2 NUTS III with positive natural growth rate. It is important to stress that in 2001-2011 there are 2 NUTS III with positive natural growth and negative migratory growth rates, making clear the transformations that are going on even in the coastal regions.

Comparing with the evolution from 1991 to 2001, the north coastal regions show in 2001-2011 a more intense change in demographic dynamics. The peripheral regions face a pervasive pattern of natural decrease of population while there is a north-south divide between negative and positive migration rates.



Source: Statistics Portugal Census 1991, 2001 and Provisional data from the 2011 Census

Figure 2 – Population growth rates (Portuguese NUTS III), 1991-2001 and 2001-2011

4. Demographic model

The demographic model we use considers the cohort component method on quinquennial age groups per sex and per NUTS III regions. Fertility and mortality rates are extrapolated from 20 years data (1990 to 2010, provided by Statistics Portugal) for sex, age group and region,

using LSE for a series of models. Data is subject to a preliminary smoothing considering data from neighbouring regions and age groups. Details on this procedure are presented in Castro et al, 2012-b (3).

Our population forecasts, developed within DEMOSPIN project, show how depressive is the demographic dynamics of the peripheral NUTS III. In the extreme case of *Pinhal Interior Sul* - a mountainous sparsely populated area - population in 2030 will be less than 60% of the 1991 census value.

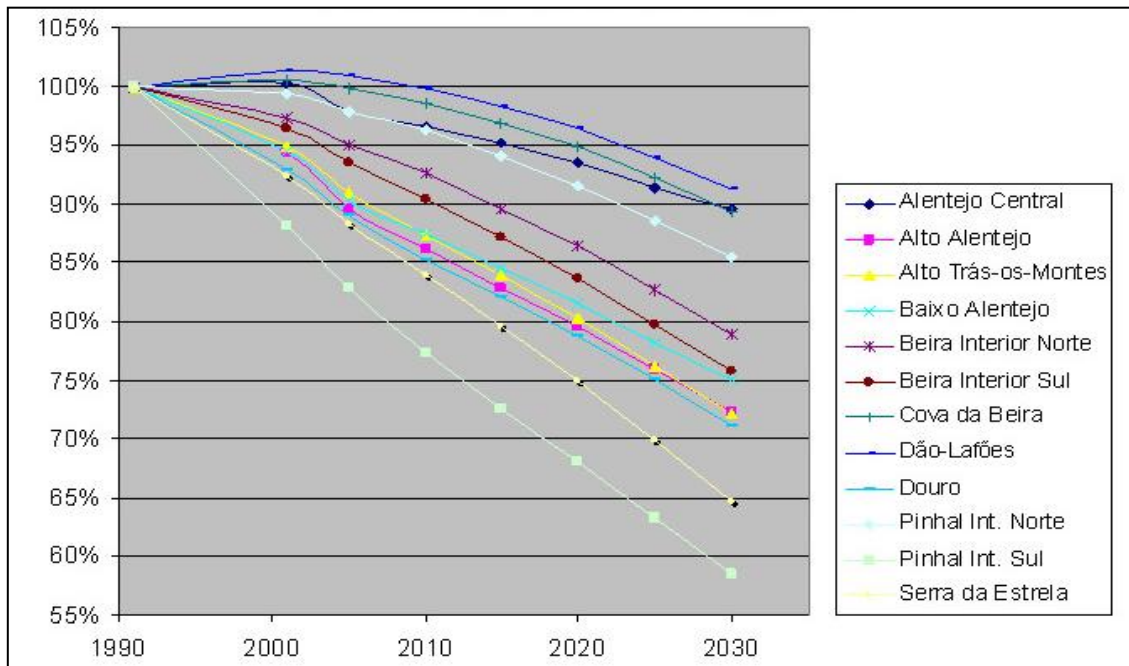


Figure 3 – Population Projections by peripheral Portuguese NUTS III

Our results are in line with the main conclusions of specialised literature, which stresses that population movements are gaining in importance, given the diminishing impact of natural change on population dynamics (Bijak, 2006 (4)). Indeed, the impact of the natural balance on population growth has decreased due to population ageing and diminishing fertility. This downward trend can only be reversed by immigration of younger working population. In fact, as mentioned by Park and Hewings (2007) (5), *attempting to change population fertility would take several years to have an impact on the economy (through labour force expansion), [while] an increase in immigration of say people aged 20-35 would have an immediate effect on the economy.*

Moreover, given the ageing levels that Portuguese peripheral regions have reached, any encouraging policy of births wouldn't be effective, due to the lack of women in childbearing age. So, the alternative is to attract young people, which move in response to job applications,

what means that immigration policies became the most effective way of intervention. However, a reasonable ex ante evaluation of any police to attract migrants through job opportunities depends on the analysis of the relationship between the stimulus and the migration outcome. This is the main objective of the migration model.

5. Migration model

As the literature demonstrates, migration is stimulated by economic and social factors (Zlotnik, 2003 (6)). Lee, 1966 (7) points out the drivers of migrations, mentioned by Ravenstein, in *The Laws of Migration* (1885): i) the propensity to migrate decreases with distance between origin and destination; ii) migration drives population upwards in the hierarchy of urban centres; iii) each migration flow tends to produce a time lagged inverse flow; iv) urban inhabitants have a lower propensity to migrate than rural people (this principle is more obvious for the ninetieth and most of the twentieth century, when the massive rural-urban exodus occurred, then for the present urban societies); v) women have a higher propensity to migrate to close destinations; vi) the improvement of transport technologies increases migrations, though there is a debate on the potential of information and communication technologies to reverse this trend (O'Brien 1992 (8); Castro et al, 2003 (9)); vii) economic motivations are the main driver of migrations. If we accept the last Ravenstein Law, economic theories are particularly important to explain migration flows as a response to regional differences in job opportunities and wages; however, economy cannot explain migrations in the two extremes of the pyramid: dependent young people and retired elderly people. As Lee, 1966 (7) noted, the selection of the migrants and their propensity to migrate also depend on the stages of the life cycle, like the entry in the labour force, marriage, divorce or widowhood. This stresses the importance of interdisciplinary studies, encompassing various theoretical perspectives: economic, sociological, mobility transition, political and systemic (Zlotnik, 2003 (6)).

5.1. Socio-economic determinants

For the Portuguese case, both for the decade 1991-2001 and 2001-2011, a relationship exists between migrations and employment opportunities, expressed by the ratio between net increase in migration and employment growth. For the working age groups between 25 and 49 years old, the relation is particularly relevant in all cases, being much weaker both for younger people - who responds more to educational opportunities - and to older people leaving the labour market.

Therefore, net migrations are calculated in the future, as a function of employment opportunities:

$$\Delta E_t = \frac{(E_E)_t - \sum ({}_n E_{Dx})_t}{({}_n P_x)_t}$$

where:

$(E_E)_t$ is the economic employment and $({}_n E_{Dx})_t$ is the demographic employment.

The disaggregation of relative net migrations (1991-2001) by age and sex sets a general pattern of net migration distribution in the peripheral regions. A similar pattern was found for the 2001-2011 decade.

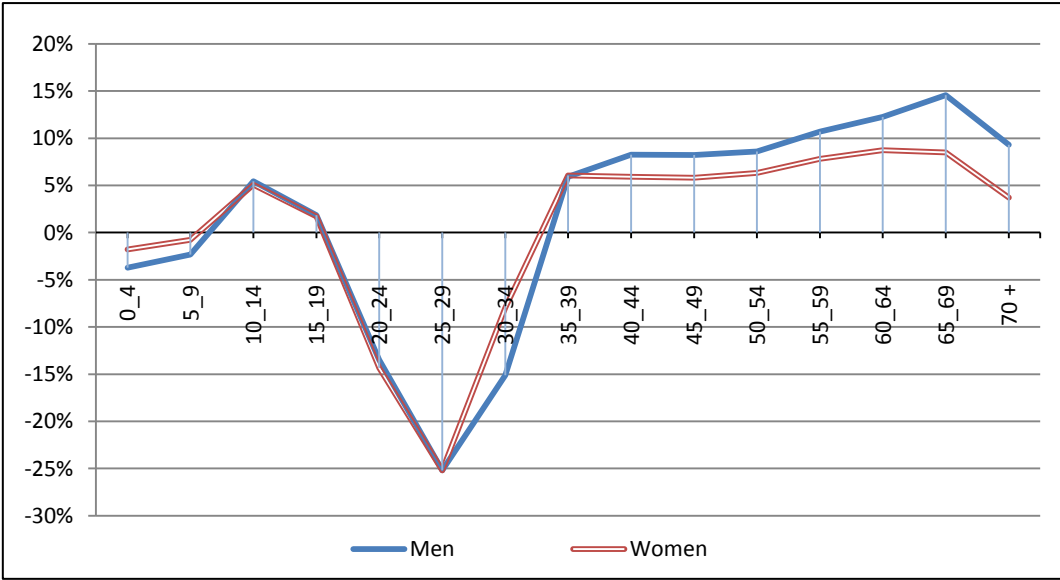


Figure 4 - Net migration patterns of the peripheral regions (1991-2001) – values are relative to population

5.2. Older age groups

The observation of Portuguese data, the analysis of relevant literature and the assumption that employment and economic performance are the main drivers of migration were the basis for a first model to forecast net migrations in all NUTS III regions (Martins et al, 2012 (12)). We found however that there was a lower explanatory capacity for older age groups. Furthermore, the return of elderly people was a key element for the linked economic input-output model, due to the significant impact on peripheral regions of demand generated by elderly population, which receive state transfers through pensions.

The results obtained with the first approach suggested that a more accurate model would be necessary to estimate migration patterns, both to people in the end of their working life and to

retired people. A preliminary analysis of available data showed a potential relation between return of older migrants and the emigration at a younger age. Another possible effect could be the migration of older people to peripheral areas to enjoy a better life quality in the retirement period of their lives. This last effect could not be spotted in the available information (Wiseman, 1980 (13)).

5.3. Detailed description

The model was therefore built including, for each age group, variables describing the rate of migration lagged by decennial intervals. There is an independent equation for each age group (from 15 to 64 years old) and sex, which estimates simultaneously net migration rates for all regions – a multiregional perspective (Rogers 1990 (9)):

$$\begin{aligned}
 {}_5M_y = & a + b {}_5(\Delta E_p)_y + c {}_5(\Delta E_{np})_y + d(\Delta GDP)_y + e(\Delta Pot)_y + \\
 & + f \left[{}_5({}_nM_{x-10})_{y-10} \right]_y + g \left[{}_5({}_nM_{x-20})_{y-20} \right]_y + \\
 & + h \left[{}_5({}_nM_{x-30})_{y-30} \right]_y + i \left[{}_5({}_nM_{x-40})_{y-40} \right]_y
 \end{aligned} \tag{eq. 1}$$

where:

$({}_nM_x)_t$ is the net migration by age group and by sex for each decade (1991-2001 and 2001-2011);

ΔE is the variation of employment opportunities in the region, given by the difference between economic and demographic employment; economic employment is given by Census data, while for future forecasts it is obtained by applying regional input-output models, one for each NUTS III, where exogenous growth stimulus are made conditional to different evolution scenarios (Ramos et al 2011 (2)); demographic employment is obtained by multiplying, for each age group (from 15 to 64 years old) and NUTS III, by a similar process, the population which would exist in 2001 (or 2011) in the absence of migrations by the employment rate in 2001; for forecasting, demographic employment is calculated; thus, the model consider the age structure changes of the population over time as a migration determinant factor (Rogers, 1990 (10)); p – primary sector and np – non-primary sector;

ΔGDP is the ratio between GDP per capita in the region and the national GDP per capita – an indicator that relates the economic performance in the origin and destination regions – being an explanatory variable which responds to the economic approach theories of

migrations (Zlotnik, 2003 (6)) and to the migration modelling theoretical framework (Termote, 2003 (11));

ΔPot is the ratio between the demographic potential in the region and the weighted average of the demographic potential of all the regions, corresponding the weights to the population of each region; demographic potential is included in order to model the effect corresponding to the second and third Ravenstein laws: the attrition of distance will induce a positive value in the coefficient d , while the trend to move upwards the urban hierarchy will have an inverse effect and thus the final value of d will represent the balance between these two opposite effects; in short, this explanatory variable represents a gravitational approach¹ of the distance factor (Termote, 2003 (11)) and may reflect the influences of spatial population distribution along the territory (Rogers, 1990 (10));

${}_nM_{x-10}$ is, for the general age group (x to $x+5$ years) and for the period $y-10$ to y years, the net migration by the present age group which is x to $x+5$ years old, for the period lagged by 10 years and when they were 10 years younger. For example, migration of age group 60 to 65 in the 90's was considered dependant on migration of 50 to 55 years old in the 80's and to migration of 40 to 45 years old in the 70's, etc.

Since migration data for Portugal is scarce, it was necessary to estimate net migrations between census as the difference between the population which occurs if net migrations in that period were zero (closed population) and the actual population. This required the collection, organization and estimation of large data sets, which included decennial census data since 1950 on population per sex, quinquennial age group and region (30 NUTS III) plus data on births and deaths per year up to 2001 with the same level of detail – only an extra age group was considered for deaths in the first year of life.

b , c , d , e are regression coefficients.

Finally, the constant a represents the propensity to migrate independently of the economic and demographic situation of the region (see the sociological and political approach theories of migration, referred in Zlotnik, 2003 (6)).

Because GDP and Pot ratios are dimensionless values, the same must happen to the demographic variables; therefore, both migrations and variation of employment opportunities, rather than being absolute numbers, are divided by the total amount of population in each age group (Rogers, 1990 (10), Termote, 2003 (11)).

¹ The demographic potential in a region is estimated by the equation $Pot_i = \sum_j \frac{P_j}{d_{ij}}$, where Pot_i (the demographic potential in the region i) is the sum of the ratios between each P_j (population of each region j) and d_{ij} (the distance from the region i to each region j).

5.4. Main results

The model presents relatively high coefficients of determination for the older age groups. The explanatory capacity of the model has been extended to the older age groups by combining the economic stimulus on the younger age groups with the historical background of migration of the region.

Figure 5 shows, for the different age groups, the coefficients of determination with r^2 lying clearly above 60% in all ages up to 74 years old.

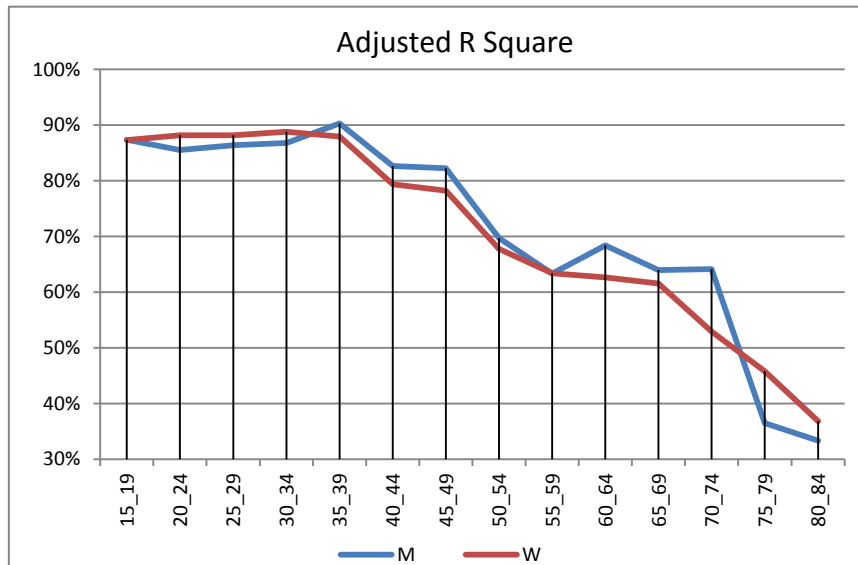


Figure 5 - The SPSS coefficients of determination

The constant a presents low values for the older active age groups meaning that the variables considered increase the explanatory capacity of the model, leaving a small role to the constant, unexplained effects (figure 6).

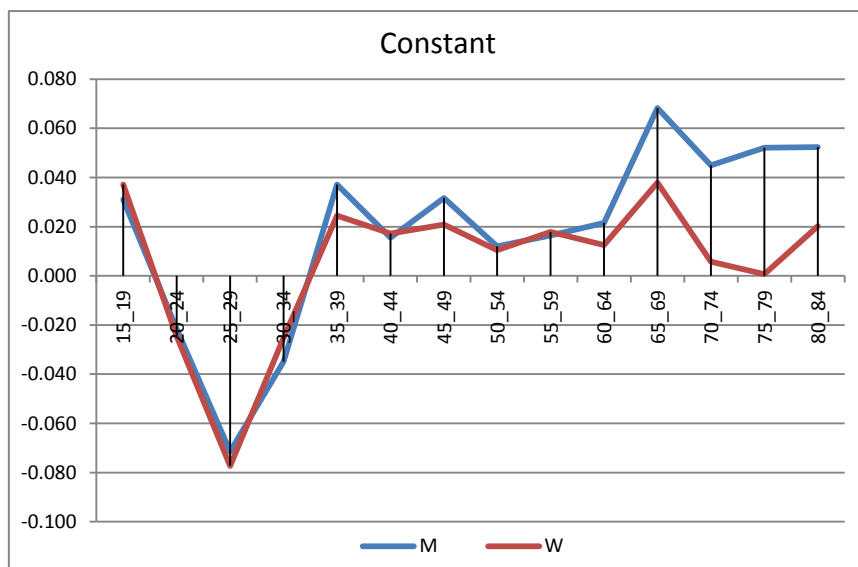


Figure 6 – Regression constant values

The coefficients b and c , corresponding to the variables *employment opportunities*, show a significant relevance for ages 25-39 and 60-74 in the primary sector and the wider impact of the non-primary sectors; as expected it presents small values for older age groups (figure 7).

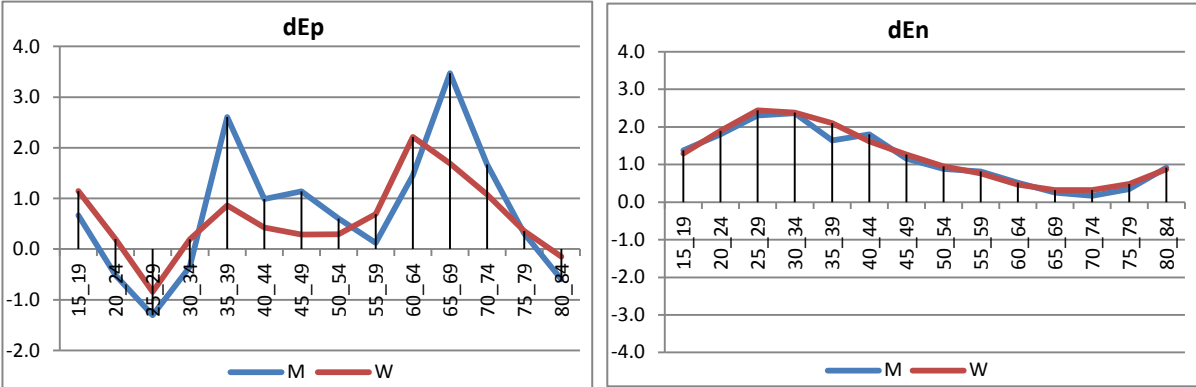


Figure 7 – employment opportunities coefficients

Both *GDP* and *demographic potential* (figures 8 and 9) show higher values for the coefficients in younger age groups and less relevant importance for older age groups.

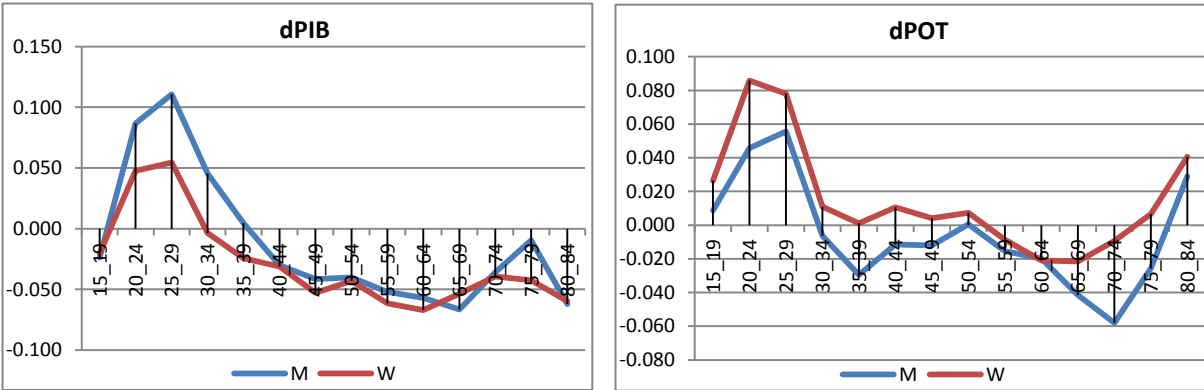


Figure 8 – GDP per capita ratio coefficients

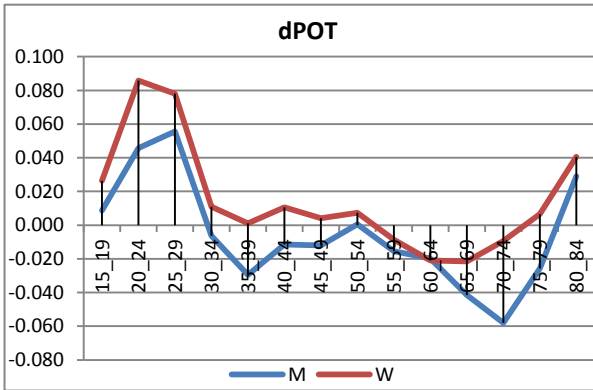


Figure 9 – Demographic potential coefficients

The analysis of the relevance of the coefficients concerning previous migration is done by Martins et al, 2013 (12)).

5.5. Younger age groups

Although people below 15 years old are not directly affected by employment opportunities, younger people are an important element of the economic module, to the extent that they generate demand and consequently affect positively the regional employment dynamics; in addition, they are a fundamental element when we forecast future population. However, younger people do not respond autonomously to migration drivers, being rather dependent upon the movements of their parents. As such, younger people migrations were estimated as a function of adult female migration, assuming that migrating mothers have the same fertility

behaviour as those resident in the host regions. This is a rough assumption which can only be substituted by more sophisticated analysis based on a sound sociological approach and fed by the required data.

6. Integration of the migration model with the demographic model

The migration model described above was used in the framework of the DEMOSPIN project:

- i) to estimate the joint evolution of the demographic and economic conditions, assuming several economic scenarios; in each time step the economic evolution depends on the demographic structure and new information is provided to feed the migration model;
- ii) to evaluate the number of new jobs that would be required to attain a certain level of population; in this approach the economy is endogenous, i.e., used to provide, e.g., the required number of jobs.

This information may be crossed, e.g., with scenarios for the evolution of fertility rates, allowing the analysis of a combination of policies (McDonald, 2002 (14)).

7. Results

Figure 10 shows a baseline representing the expected evolution of the closed population of NUTS III Dão-Lafões until 2085 – we assume constant employment, fertility and mortality rates after 2050. The dashed line represents, as an example, the demographic evolution if we guarantee the existence of 500 jobs (~5% of total employment) above the demographic employment. Finally the upper lines represent the effects of both the 500 extra jobs till 2030 plus the evolution of the total fertility rate (TFR) towards 2.1 by 2030.

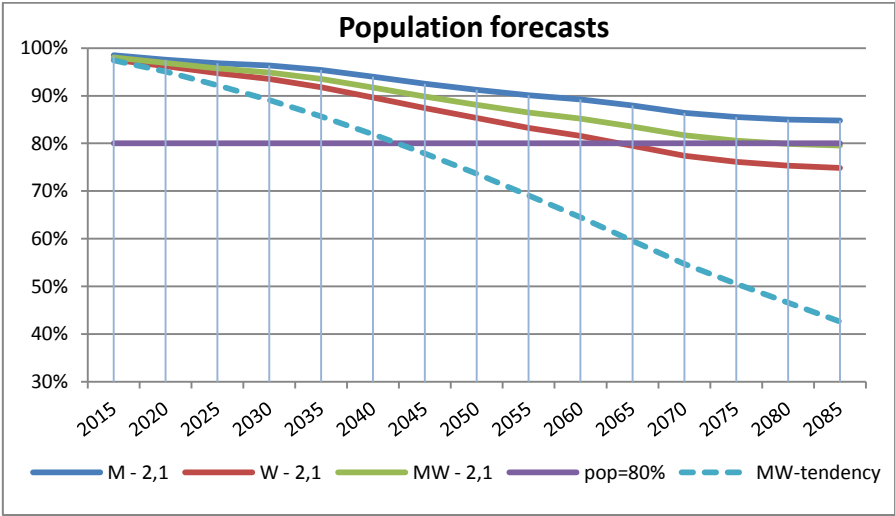


Figure 10: Population forecasts of NUTS III Dão-Lafões, under different scenarios

The model allows the user to set a target population in 2100, providing information on the number of required migrants to achieve that goal, either under the modelled fertility rates or under other restrictions.

8. Conclusions

The work developed by DEMOSPIN project revealed the extent of the human desertification problem in almost all Portuguese peripheral regions and how difficult will it be to reverse the trend. It showed also that only the attraction of younger people, through job opportunities, can reverse the situation.

A model was developed which describes the relation between migration, by age group, and employment, GDP, demography. Considering the importance of the migration of older people to the regional economy, the model was built in order to represent also these groups. It considers the above referred variables, plus the information on migration of the relevant age groups in previous decades. The model represents therefore the migrations between 15 and 84 years old with relatively high regression coefficients. A satellite model relates these migrations with migrant children 0 to 14 years old.

The migration model was integrated into the demographic model and on the combined economic-demographic model. Results show the potential of this tool for the evaluation and analysis of alternative scenarios, both related to the creation/destruction of jobs and/or to changes in fertility rates.

Taking into account that many other regions in Europe are witnessing the same aging effects, the model could be further validated for these other regions. The tool developed may be adapted to forecast population evolution in peripheral regions and will be a valuable aid in the support for decision making in the implementation of public policies to address these problems.

Acknowledgements

The authors thank the Portuguese Foundation for Science and Technology for the support provided to the DEMOSPIN project, PTDC/CS-DEM/100530/2008, and also GOVCOPP - Research Unit in Governance, Competitiveness and Public Policies of the University of Aveiro.

References

1. Castro, E., Gomes, C., Silva, C., Martins, J. (2012), *An inter-regional migration model applied to Portuguese data*, European Population Conference 2012, Stockholm.
2. Ramos, P., Castro, E., Cruz, L. (2011), *Economically sustainable demography: reversing decline in Portuguese peripheral regions*, 19th International Input-Output Conference, Alexandria VA, EUA.
3. Castro, E., Ramos, P., Silva, C. (2012), *The dynamics of depressive peripheral areas – DEMOSPIN model*, RSAI, Ottawa.
4. Bijak, J. (2006), *Forecasting International Migration: Selected Theories, Models and Methods*, Central European Forum For Migration Research, Varsóvia.
5. Park, S., Hewings, G. (2007), *Immigration, Aging and the Regional Economy*, Regional Economics Applications Laboratory (REAL), Illinois.
6. Zlotnik, H. (2003), *Théories sur les migrations internationales*, Démographie: analyse et synthèse, Les déterminants de la migration, Institut national d'études démographiques (INED), Paris, pp. 55-78.
7. Lee, E. (1966), *A Theory of Migration*, Demography, Vol. 1, pp. 45-57.
8. O'Brien, R. (1992), *Global financial integration: The end of geography*, Pinter Publishers, London.
9. Castro, E., Butler, C. (2003), *Demand for information and communication technology-based services and regional economic development*, Papers in Regional Science, Vol. 82, Issue 1, pp. 27-50.
10. Rogers, A. (1990), *Requiem for the Net Migrant*, Geographic Analysis, Ohio State University Press, Vol. 22. N° 4, pp. 283-300.
11. Termote, M. (2003), *Les déterminants économiques de la migration*, Démographie: analyse et synthèse, Les déterminants de la migration, INED, Paris, pp. 83-100.
12. Martins, J., Castro, E., Silva, C. (2012), *Modeling migration between different regions in a country*, RSAI, Ottawa.
13. Wiseman, R., *Why Older People Move – Theoretical Issues*, Research on Aging, Vol. 2, N° 2 (Jun., 1980), pp. 141-154, Sage Publications, Inc, (1980).
14. McDonald, P. (2002), *Sustaining Fertility through Public Policy: The Range of Options*, Population, 2002/3, Vol. 57, pp. 417- 446.